STYLEFORMER

A Convolution-Free Style Image Generator based on Transformer And Stylegan2.

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STRONG STYLE GENERATOR CONVOLUTION - FREE

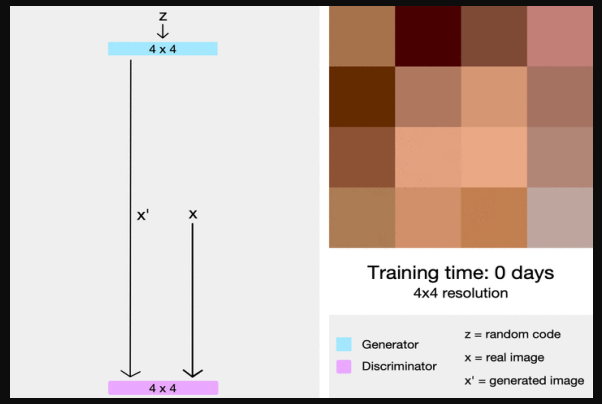
GAN's (Generative Adversarial Networks) models are living a huge success since their introduction in 2014. Nowadays resolution and quality of the generated images increased a lot, despite that, there is something that doesn't changed, the consideration of convolutional backbones as fundamental to achieve high-resolution images and a stable training. In this work, we have tried to implement a strong, and light, style-based generator designed with a convolution-free structure based on NPL technologies such as Transformer and Attention.

TECH OVERVIEW

How GAN works and why we are trying to use NPL technologies to generate images.

STYLE GENERATIVE ADVERSARIAL NETWORK

- First GAN model was introduced by Ian Goodfellow in 2014.
- StyleGAN is a progressive growing GAN architecture, able to synthesizing high resolution and quality images with incremental growing of discriminator and generator.



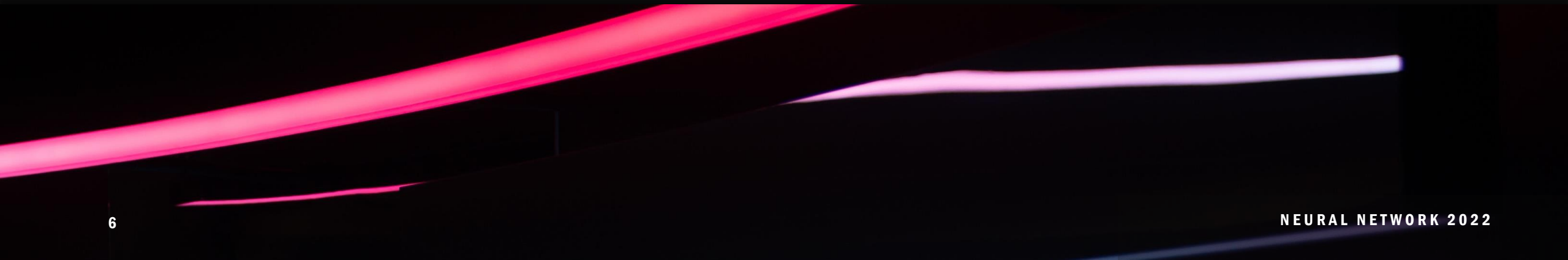
- That model shows some problems in generation, StyleGAN2 addressed most them using skip connection and replacing AdaIN with a statistic-based approach.
- Some problem remains, shortcomings derived using a convolutional network such locality problem led to a difficult capture of the global features.

ALL YOU NEED IS TRANSFORMER

- *"The first transduction model* ***relying entirely on self-attention*** *to compute representations of its input and output without using sequence-aligned RNNs or convolution"*
- Designed for **NPL**, recently is rising as an alternative to convolution operation in the computer vision field.
- Based on **attention**, a mechanism that mimic the cognitive attention focusing on small but significative details of an image, a token or any other significative data.
- Stacking attention and combining them with feed-forward layers, we can form encoders (**self-attention**).

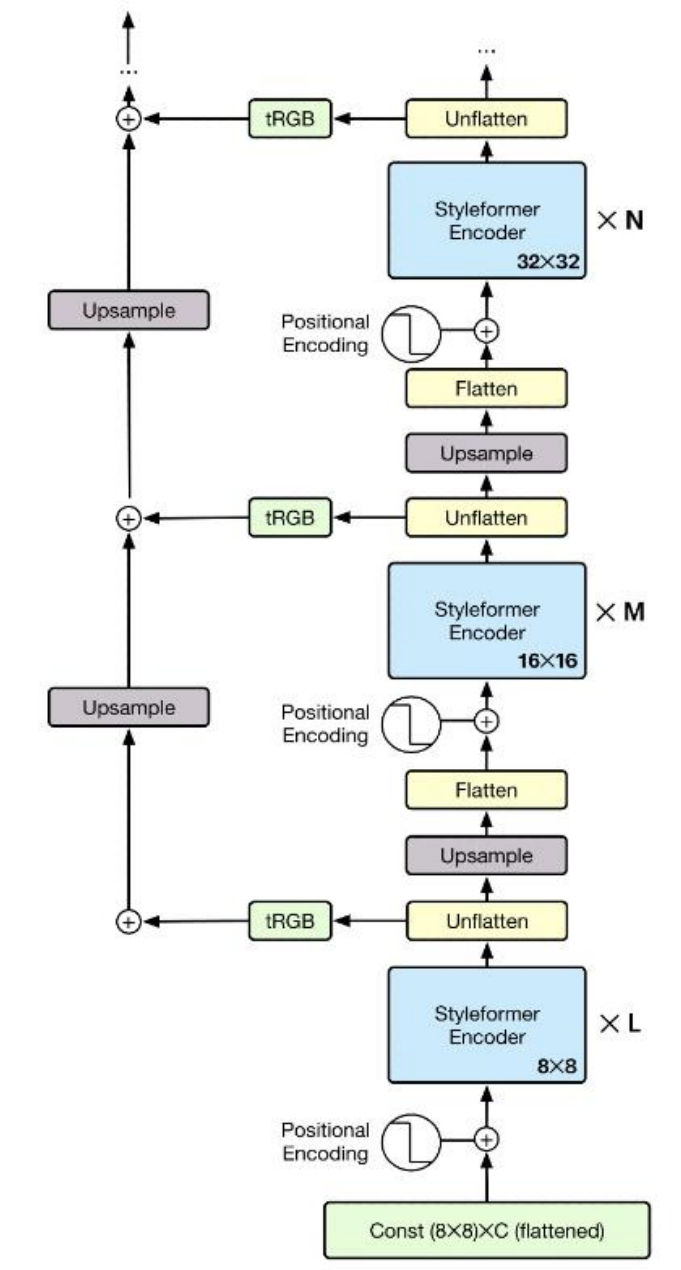
ALL YOU NEED IS TRANSFORMER

- Solves the difficult to capture long-range dependency without stacking multiple layers.
- Indeed, using self-attention we are able to capture long-range dependency and understand global features efficiently.
- Using Linformer we can address Transformer expensive cost while dealing with high-resolution images.



ARCHITECTURE OVERVIEW

How Styleformer is built, which are the main components and how it works



ARCHITECTURE

- Styleformer generator is conditioned on a learnable constant input and combined with a learnable positional encoding.
- The constant input(8x8) is flattened(64) to enter the Transformer-based encoder, then the Styleformer encoder.
- Each resolution passes through several encoder blocks. → Bilinear upsample operation. → Adding positional encoding.
- Repeat until reaches the target image resolution.

ARCHITECTURE
ENCODER BLOCK

- We need a Transformer-based generator
- We need a style modulation and demodulation methods

Attention mechanism can be seen as built in two steps

1. preparation module: compute Query, Key and Value
2. main module: attention operation is applied

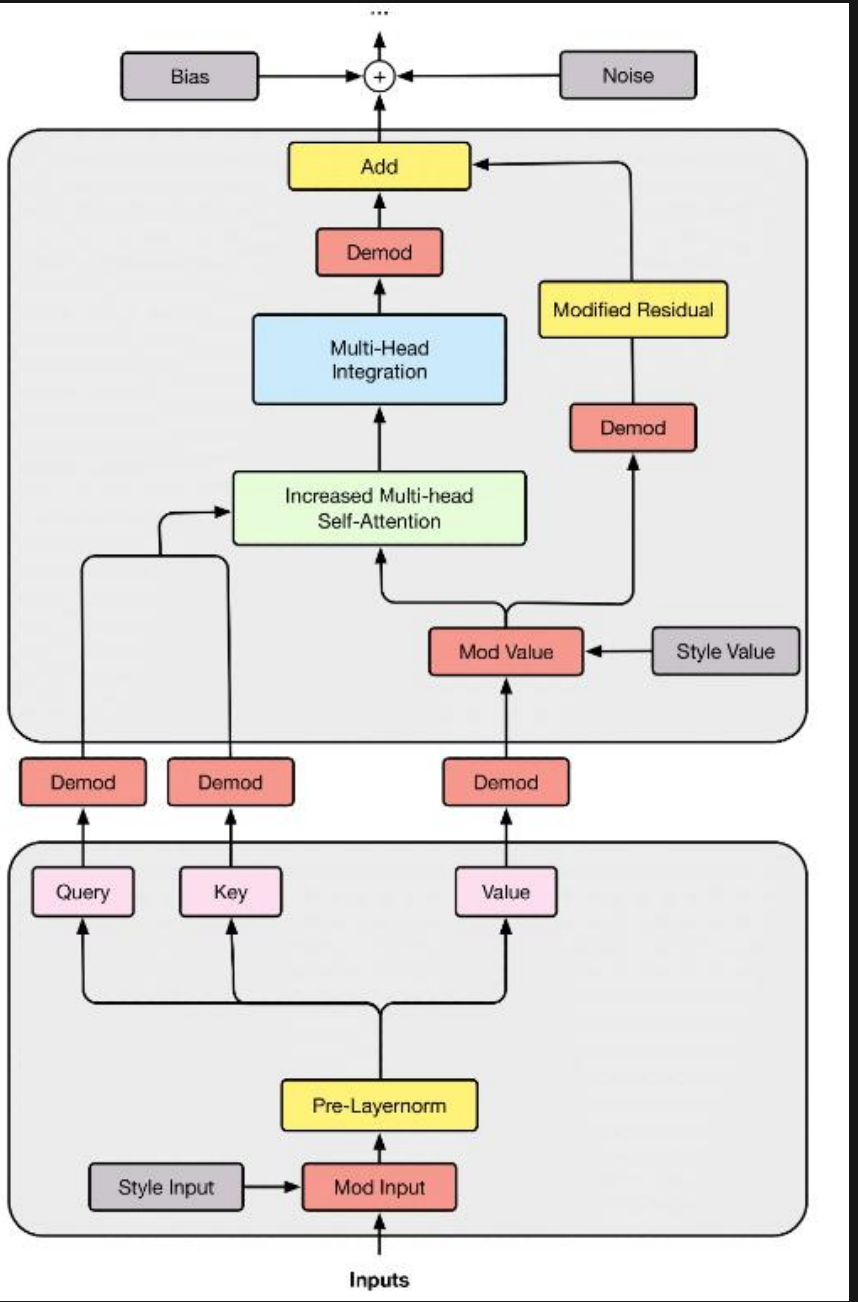
COMPUTING ATTENTION

- Preparation module is a module that creates Quey, Key and Value to conduct attention:

$$Q_i = XW_i^Q,\ K_i = XW_i^K,\ V_i = XW_i^V$$

- Main module is a module that performs attention operation:

$$A_i = softmax(\frac{Q_i K_i^T}{\sqrt{d_k}}),$$
$$head_i = A_i V_i,$$
$$Multihead(Q, K, V) = Concat(head_1, \ldots, head_k)W^O$$



ARCHITECTURE

FOCUS ON ENCODER BLOCK

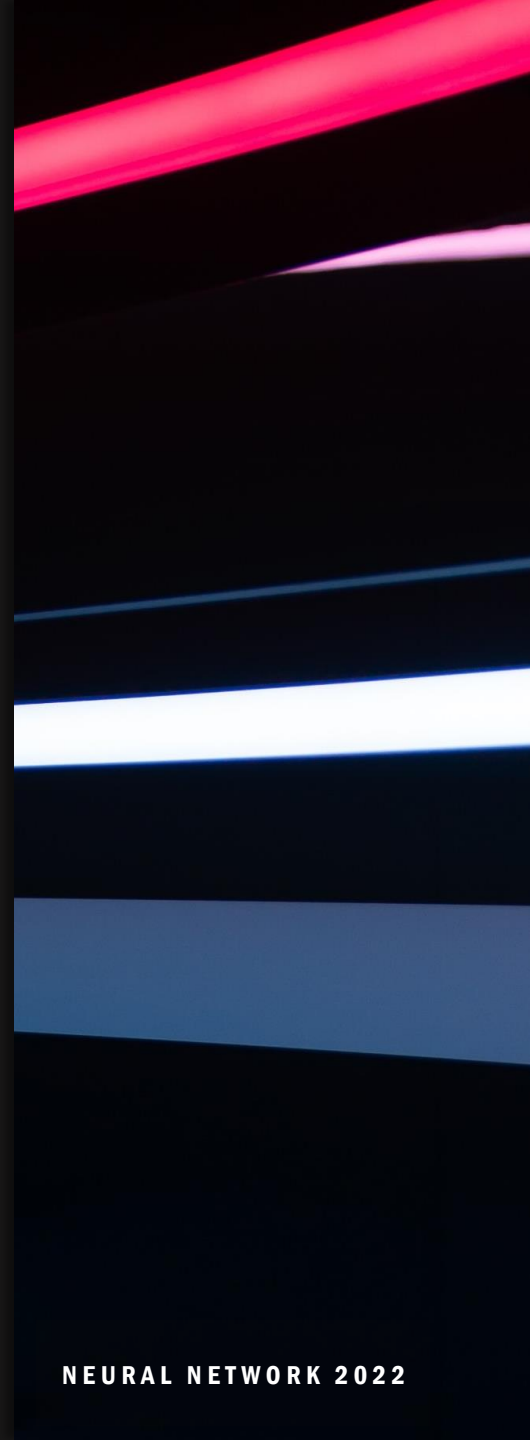
- Pre-Layer Normalization procedure
- Prepare module: demodulation of Query, Key and Value
- Core of Self-Attention: production of the attention map and the weighted sum of V with attention map itself
- Increased the number of head of multi-head attention ⟶ the created attention map will be different for each head
- Further demodulation
- Add bias and noise at end of each blocks

CONCLUSIONS

HOW GOOD STYLEFORM IS?

CIFAR-10	FID	IS
PROGRESSIVE GAN	15.52	8.80
TRANSGAN	9.26	9.02
STYLEGAN2	2.92	9.83
STYLEFORMER	2.82	10.0

- CIFAR-10 is widely used as a benchmark dataset. They used 50K images(32x32) at the training set, without using label.
- We have used two of the most known metrics for image evaluation:
- **Fréchet Inception Distance,** known as FID, is a method for comparing the statistics of two distributions by computing the distance between them
- **Inception score,** known as ID, popular metric for judging the image outputs of GAN which measure of how realistic a GAN's output is.



CONCLUSIONS

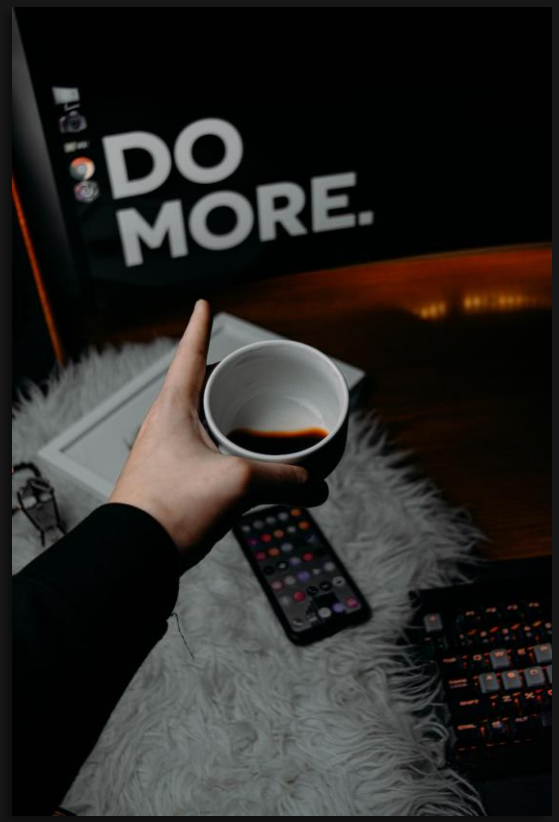
WHAT WE EXPERIMENTED ON COLAB?

- Training and image generation.
- Assembling a custom and topic-based dataset to train on it.
- Assembling generate images to achieve a morph effect.
- Exploring latent vectors direction performing fine tune.

CONCLUSIONS

WHAT'S NEXT?

- Test Styleformer with high end resources to have better train results in less time.
- Reduce the computational cost to test with higher-resolution images.
- Redesign also the discriminator to use Transformer.
- Porting this project to Stylegan3.



THANK YOU!

- Styleformer Implementation
- Google Colab Notebook
- Fabio Caputo
- Weihao Peng